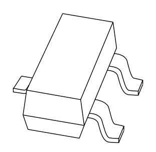


TL431 family

Adjustable precision shunt regulator

Rev. 02 — 20 January 2010 | Product data sheet

1. General description

Three-terminal shunt regulator family with an output voltage range between V_{ref} and 36 V, to be set by two external resistors.

Table 1. Product overview

Reference voltage tolerance (V_{ref})	Temperature range (T_{amb})			Pinning configuration (see Table 5)
	0 to 70 °C	−40 to 85 °C	−40 to 125 °C	
2 %	TL431CDBZR	TL431IDBZR	TL431QDBZR	normal pinning
			TL431SDT	normal pinning
			TL431MSDT	mirrored pinning
1 %	TL431ACDBZR	TL431AIDBZR	TL431AQDBZR	normal pinning
			TL431ASDT	normal pinning
			TL431AMSDT	mirrored pinning
0.5 %	TL431BCDBZR	TL431BIDBZR	TL431BQDBZR	normal pinning
			TL431BSDT	normal pinning
			TL431BMSDT	mirrored pinning

2. Features

- Programmable output voltage up to 36 V
- Three different reference voltage tolerances:
  - Standard grade: 2 %
  - A-Grade: 1 %
  - B-Grade: 0.5 %
- Typical temperature drift: 6 mV (in a range of 0 °C up to 70 °C)
- Low output noise
- Typical output impedance: 0.2 Ω
- Sink current capability: 1 mA to 100 mA
- AEC-Q100 qualified (grade 1)

3. Applications

- Shunt regulator
- Precision current limiter
- Precision constant current sink



4. Quick reference data

Table 2. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{KA}	cathode-anode voltage		V_{ref}	-	36	V
I_K	cathode current		1	-	100	mA
V_{ref}	reference voltage	$V_{KA} = V_{ref}$; $I_K = 10$ mA				
	Standard-Grade (2 %)		2440	2495	2550	mV
	A-Grade (1 %)		2470	2495	2520	mV
	B-Grade (0.5 %)		2483	2495	2507	mV

5. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
TL431CDBZR	-	plastic surface-mounted package; 3 leads	SOT23
TL431IDBZR			
TL431QDBZR			
TL431SDT			
TL431MSDT			
TL431ACDBZR			
TL431AIDBZR			
TL431AQDBZR			
TL431ASDT			
TL431AMSDT			
TL431BCDBZR			
TL431BIDBZR			
TL431BQDBZR			
TL431BSDT			
TL431BMSDT			

6. Marking

Table 4. Marking codes

Type number	Marking code[1]	Type number	Marking code[1]
TL431CDBZR	CA*	TL431ASDT	RL*
TL431IDBZR	CB*	TL431AMSDT	LQ*
TL431QDBZR	CC*	TL431BCDBZR	CG*
TL431SDT	RM*	TL431BIDBZR	CH*
TL431MSDT	LR*	TL431BQDBZR	CJ*
TL431ACDBZR	CD*	TL431BSDT	MA*
TL431AIDBZR	CE*	TL431BMSDT	MB*
TL431AQDBZR	CF*	-	-

[1] * = -: made in Hong Kong
* = p: made in Hong Kong
* = t: made in Malaysia
* = W: made in China

7. Functional diagram

The TL431 family comprises a range of 3-terminal adjustable shunt regulators, with specified thermal stability over applicable automotive and commercial temperature ranges. The output voltage may be set to any value between V_{ref} (approximately 2.5 V) and 36 V with two external resistors (see Figure 8). These devices have a typical output impedance of 0.2 Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for Zener diodes in many applications like on-board regulation, adjustable power supplies and switching power supplies.

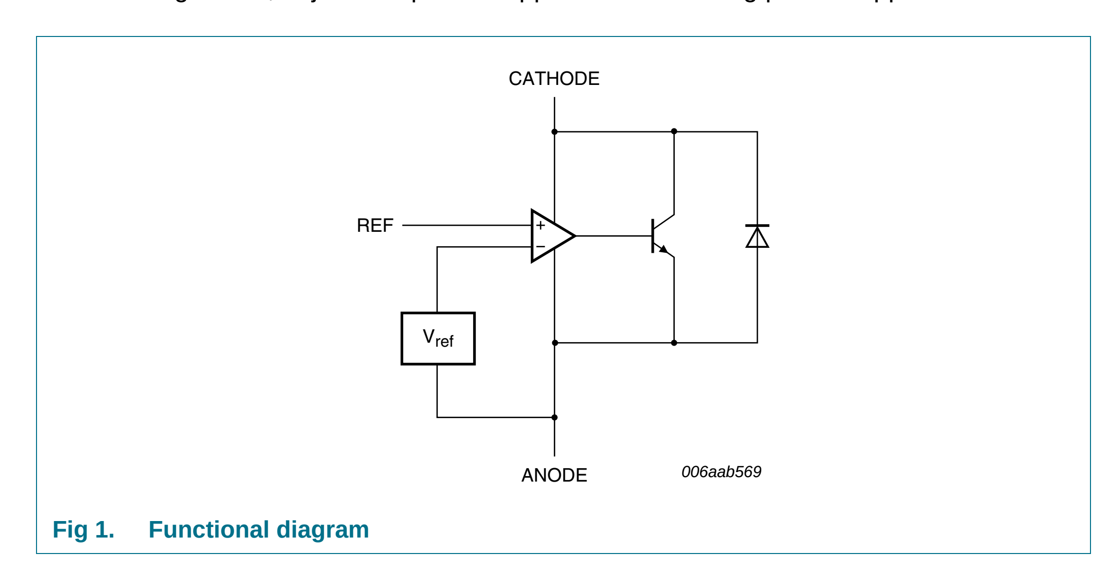


Fig 1. Functional diagram

8. Pinning information

Table 5. Pinning

Pin	Symbol	Description	Simplified outline	Graphic symbol
Normal pinning: All types except TL431AMSDT, TL431BMSDT and TL431MSDT				
1	k	cathode		
2	REF	reference		
3	a	anode		
Mirrored pinning: TL431AMSDT, TL431BMSDT and TL431MSDT				
1	REF	reference		
2	k	cathode		
3	a	anode		

9. Limiting values

Table 6. Limiting values

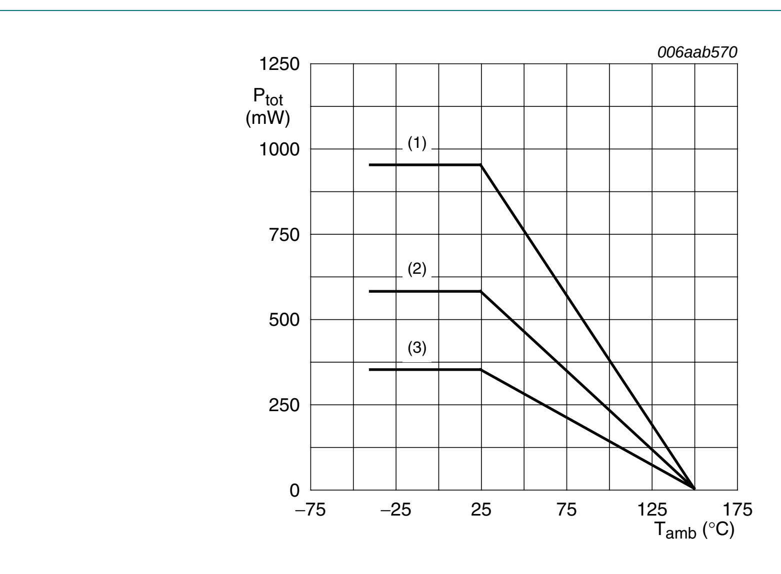
In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions		Min	Max	Unit
V_{KA}	cathode-anode voltage			-	37	V
I_K	cathode current			−100	150	mA
I_{ref}	reference current			−0.05	10	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C	[1]	-	350	mW
			[2]	-	580	mW
			[3]	-	950	mW
T_j	junction temperature			-	150	°C
T_{amb}	ambient temperature					
	TL431XCDBZR			0	+70	°C
	TL431XIDBZR			−40	+85	°C
	TL431XQDBZR TL431XSDT			−40	+125	°C
T_{stg}	storage temperature			−65	+150	°C

[1] Device mounted on an FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated and standard footprint.

[2] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2.

[3] Device mounted on a ceramic PCB, Al_2O_3, standard footprint.



(1) Ceramic PCB, Al_2O_3, standard footprint

(2) FR4 PCB, mounting pad for collector 1 cm^2

(3) FR4 PCB, standard footprint

Fig 2. Power derating curves

Table 7. ESD maximum ratings

T_{amb} = 25 °C unless otherwise specified.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{ESD}	electrostatic discharge voltage	MIL-STD-883 (human body model)	-	4	kV

10. Recommended operating conditions

Table 8. Operating conditions

Symbol	Parameter	Conditions	Min	Max	Unit
V_{KA}	cathode-anode voltage		V_{ref}	36	V
I_K	cathode current		1	100	mA

11. Thermal characteristics

Table 9. Thermal characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	[1]	-	-	360	K/W
			[2]	-	-	216	K/W
			[3]	-	-	132	K/W
$R_{th(j-sp)}$	thermal resistance from junction to solder point		[4]	-	-	50	K/W

[1] Device mounted on an FR4 PCB, single-sided copper, tin-plated and standard footprint.

[2] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2.

[3] Device mounted on a ceramic PCB, Al_2O_3, standard footprint.

[4] Soldering point at pin 3.

12. Characteristics

Table 10. Characteristics

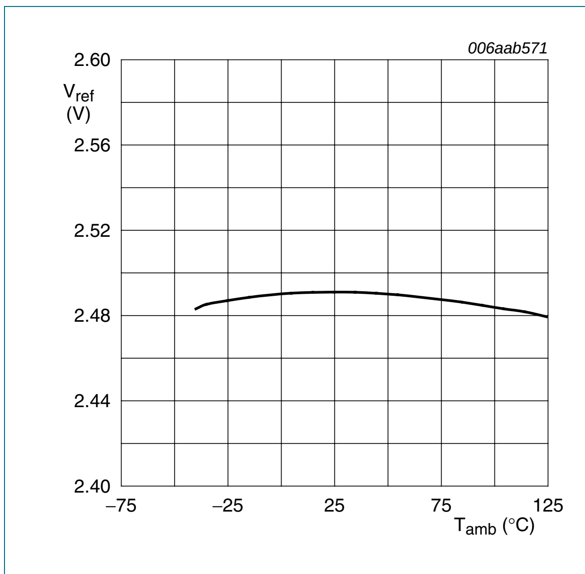
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Standard-Grade (2 %): TL431CDBZR; TL431IDBZR; TL431QDBZR; TL431SDT; TL431MSDT						
V_{ref}	reference voltage	$V_{KA} = V_{ref}$; $I_K = 10$ mA	2440	2495	2550	mV
ΔV_{ref}	reference voltage variation	$V_{KA} = V_{ref}$; $I_K = 10$ mA				
	TL431CDBZR	$T_{amb} = 0$ °C to 70 °C	-	6	16	mV
	TL431IDBZR	$T_{amb} = -40$ °C to 85 °C	-	14	34	mV
	TL431QDBZR TL431SDT TL431MSDT	$T_{amb} = -40$ °C to 125 °C				
$\Delta V_{ref}/\Delta V_{KA}$	reference voltage variation to cathode-anode voltage variation ratio	$I_K = 10$ mA				
		$\Delta V_{KA} = 10$ V to V_{ref}	-	–1.4	–2.7	mV/V
		$\Delta V_{KA} = 36$ V to 10 V	-	–1	–2	mV/V
I_{ref}	reference current	$I_K = 10$ mA; R1 = 10 kΩ; R2 = open	-	2	4	µA
ΔI_{ref}	reference current variation	$I_K = 10$ mA; R1 = 10 kΩ; R2 = open				
	TL431CDBZR	$T_{amb} = 0$ °C to 70 °C	-	0.4	1.2	µA
	TL431IDBZR	$T_{amb} = -40$ °C to 85 °C	-	0.8	2.5	µA
	TL431QDBZR TL431SDT TL431MSDT	$T_{amb} = -40$ °C to 125 °C				
$I_{K(min)}$	minimum cathode current	$V_{KA} = V_{ref}$	-	0.4	1	mA
I_{off}	off-state current	$V_{KA} = 36$ V; $V_{ref} = 0$	-	0.1	1	µA
Z_{KA}	dynamic cathode-anode impedance	$I_K = 1$ mA to 100 mA; $V_{KA} = V_{ref}$; f < 1 kHz	-	0.2	0.5	Ω

Table 10. Characteristics *...continued*

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
A-Grade (1 %): TL431ACDBZR; TL431AIDBZR; TL431AQDBZR; TL431ASDT; TL431AMSDT						
V_{ref}	reference voltage	$V_{KA} = V_{ref}$; $I_K = 10$ mA	2470	2495	2520	mV
ΔV_{ref}	reference voltage variation	$V_{KA} = V_{ref}$; $I_K = 10$ mA				
	TL431ACDBZR	$T_{amb} = 0$ °C to 70 °C	-	6	16	mV
	TL431AIDBZR	$T_{amb} = -40$ °C to 85 °C	-	14	34	mV
	TL431AQDBZR TL431ASDT TL431AMSDT	$T_{amb} = -40$ °C to 125 °C				
$\Delta V_{ref}/\Delta V_{KA}$	reference voltage variation to cathode-anode voltage variation ratio	$I_K = 10$ mA				
		$\Delta V_{KA} = 10$ V to V_{ref}	-	–1.4	–2.7	mV/V
		$\Delta V_{KA} = 36$ V to 10 V	-	–1	–2	mV/V
I_{ref}	reference current	$I_K = 10$ mA; R1 = 10 kΩ; R2 = open	-	2	4	µA
ΔI_{ref}	reference current variation	$I_K = 10$ mA; R1 = 10 kΩ; R2 = open				
	TL431ACDBZR	$T_{amb} = 0$ °C to 70 °C	-	0.4	1.2	µA
	TL431AIDBZR	$T_{amb} = -40$ °C to 85 °C	-	0.8	2.5	µA
	TL431AQDBZR TL431ASDT TL431AMSDT	$T_{amb} = -40$ °C to 125 °C				
$I_{K(min)}$	minimum cathode current	$V_{KA} = V_{ref}$				
	TL431ACDBZR	$T_{amb} = 0$ °C to 70 °C	-	0.4	0.6	mA
	TL431AIDBZR	$T_{amb} = -40$ °C to 85 °C	-	0.4	0.7	mA
	TL431AQDBZR TL431ASDT TL431AMSDT	$T_{amb} = -40$ °C to 125 °C				
I_{off}	off-state current	$V_{KA} = 36$ V; $V_{ref} = 0$	-	0.1	0.5	µA
Z_{KA}	dynamic cathode-anode impedance	$I_K = 1$ mA to 100 mA; $V_{KA} = V_{ref}$; f < 1 kHz	-	0.2	0.5	Ω
B-Grade (0.5 %): TL431BCDBZR; TL431BIDBZR; TL431BQDBZR; TL431BSDT; TL431BMSDT						
V_{ref}	reference voltage	$V_{KA} = V_{ref}$; $I_K = 10$ mA	2483	2495	2507	mV
ΔV_{ref}	reference voltage variation	$V_{KA} = V_{ref}$; $I_K = 10$ mA				
	TL431BCDBZR	$T_{amb} = 0$ °C to 70 °C	-	6	16	mV
	TL431BIDBZR	$T_{amb} = -40$ °C to 85 °C	-	14	34	mV
	TL431BQDBZR TL431BSDT TL431BMSDT	$T_{amb} = -40$ °C to 125 °C				
$\Delta V_{ref}/\Delta V_{KA}$	reference voltage variation to cathode-anode voltage variation ratio	$I_K = 10$ mA				
		$\Delta V_{KA} = 10$ V to V_{ref}	-	–1.4	–2.7	mV/V
		$\Delta V_{KA} = 36$ V to 10 V	-	–1	–2	mV/V
I_{ref}	reference current	$I_K = 10$ mA; R1 = 10 kΩ; R2 = open	-	2	4	µA

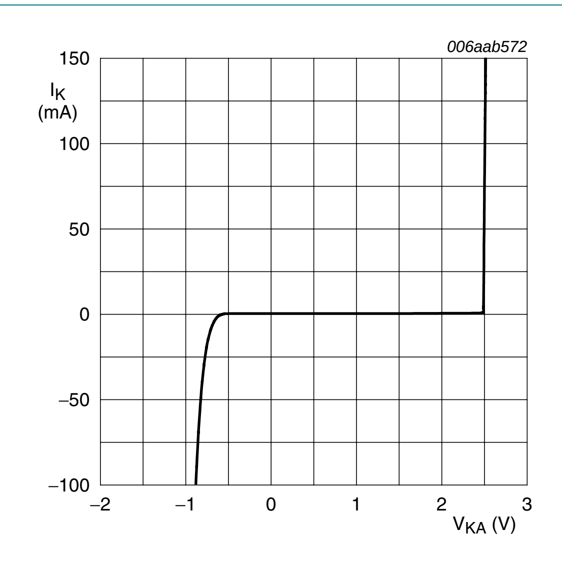
Table 10. Characteristics *…continued*

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ΔI_{ref}	reference current variation	I_K = 10 mA; R1 = 10 kΩ; R2 = open				
	TL431BCDBZR	T_{amb} = 0 °C to 70 °C	-	0.4	1.2	μA
	TL431BIDBZR	T_{amb} = –40 °C to 85 °C	-	0.8	2.5	μA
	TL431BQDBZR TL431BSDT TL431BMSDT	T_{amb} = –40 °C to 125 °C				
$I_{K(min)}$	minimum cathode current	$V_{KA} = V_{ref}$				
	TL431BCDBZR	T_{amb} = 0 °C to 70 °C	-	0.4	0.6	mA
	TL431BIDBZR	T_{amb} = –40 °C to 85 °C	-	0.4	0.7	mA
	TL431BQDBZR TL431BSDT TL431BMSDT	T_{amb} = –40 °C to 125 °C				
I_{off}	off-state current	V_{KA} = 36 V; V_{ref} = 0	-	0.1	0.5	μA
Z_{KA}	dynamic cathode-anode impedance	I_K = 1 mA to 100 mA; $V_{KA} = V_{ref}$; f < 1 kHz	-	0.2	0.5	Ω



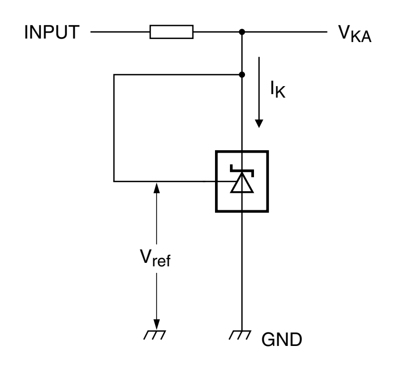
I_K = 10 mA; V_{KA} = V_{ref}

Fig 3. Reference voltage as a function of ambient temperature; typical values



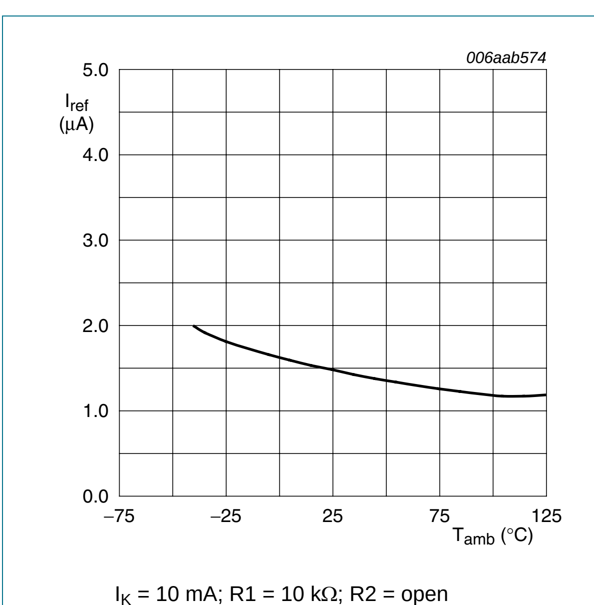
V_{KA} = V_{ref}; T_{amb} = 25 °C

Fig 4. Cathode current as a function of cathode-anode voltage; typical values



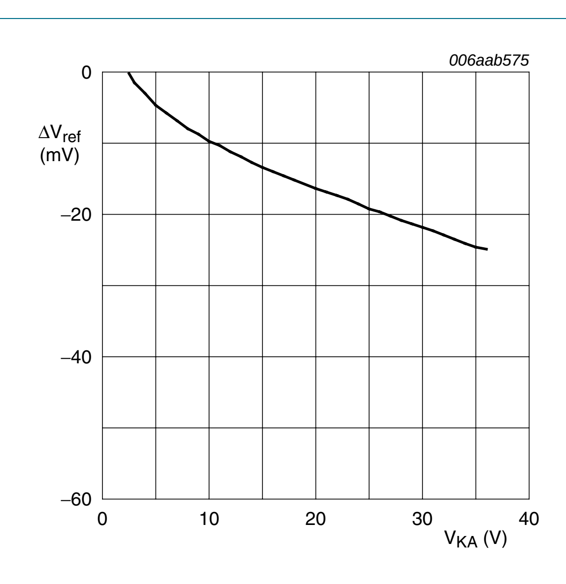
I_K = 10 mA; V_{KA} = V_{ref}

Fig 5. Test circuit to Figure 3 and Figure 4



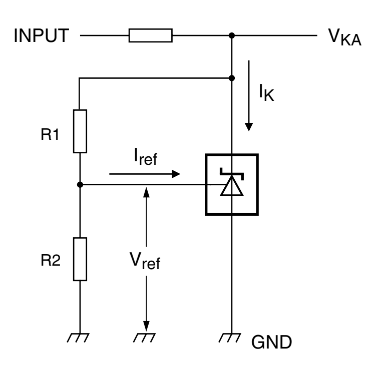
I_K = 10 mA; R1 = 10 kΩ; R2 = open

Fig 6. Reference current as a function of ambient temperature; typical values



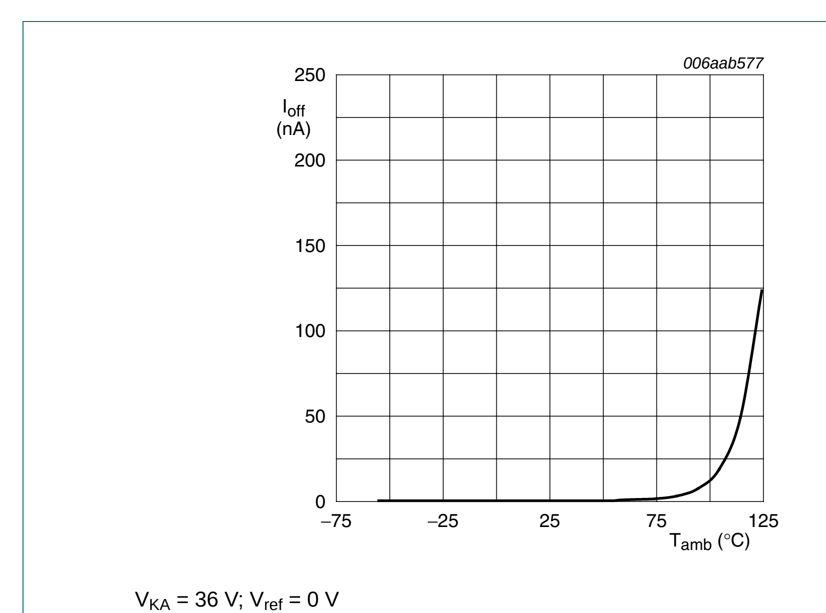
I_K = 10 mA; T_{amb} = 25 °C

Fig 7. Reference voltage variation as a function of cathode-anode voltage; typical values



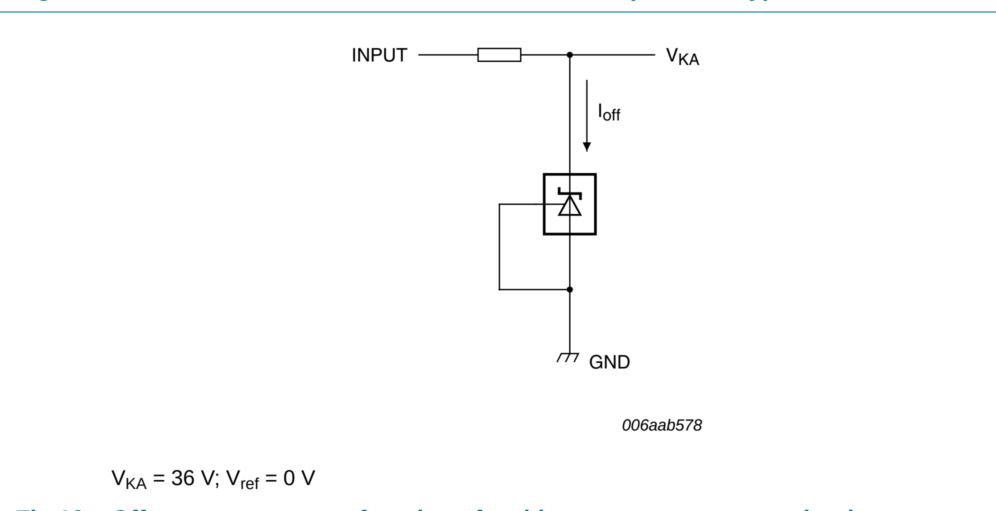
$$V_{KA} = V_{ref} \times \left(1 + \frac{R1}{R2}\right) + I_{ref} \times R1$$

Fig 8. Test circuit to Figure 6 and Figure 7



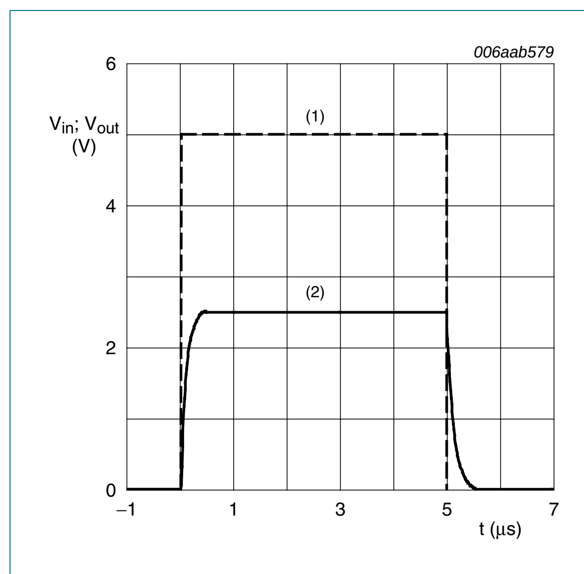
V_{KA} = 36 V; V_{ref} = 0 V

Fig 9. Off-state current as a function of ambient temperature; typical values



V_{KA} = 36 V; V_{ref} = 0 V

Fig 10. Off-state current as a function of ambient temperature; test circuit

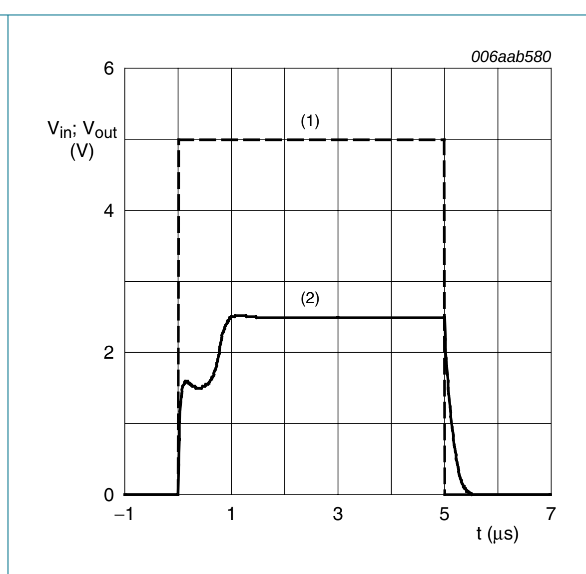


T_{amb} = 25 °C

(1) Input

(2) Output

Fig 11. All types except TL431XSDT: Input voltage and output voltage as a function of time; typical values

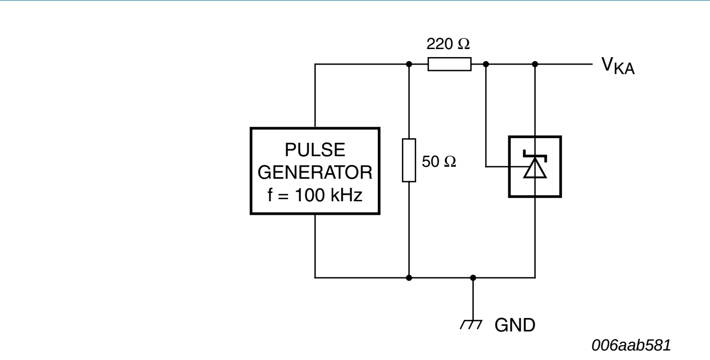


T_{amb} = 25 °C

(1) Input

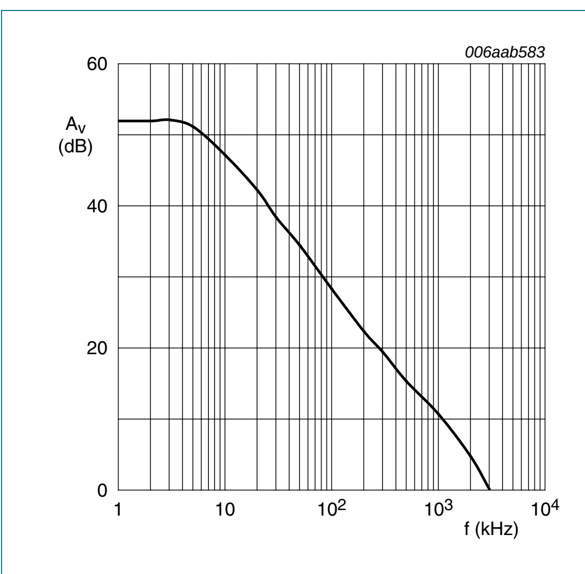
(2) Output

Fig 12. TL431XSDT: Input voltage and output voltage as a function of time; typical values



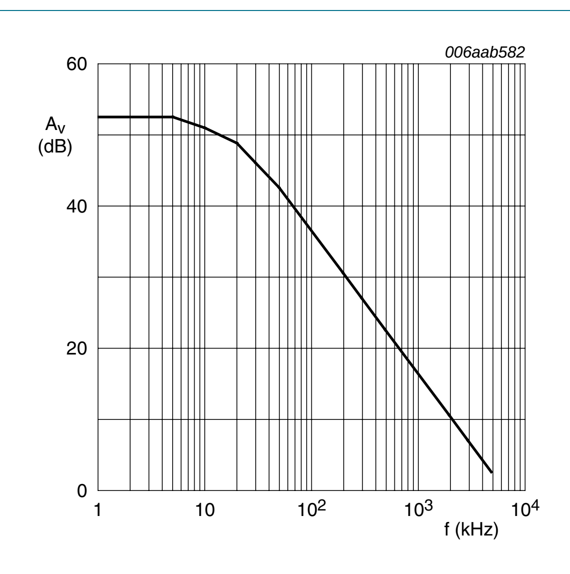
T_{amb} = 25 °C

Fig 13. Test circuit to Figure 11 and Figure 12



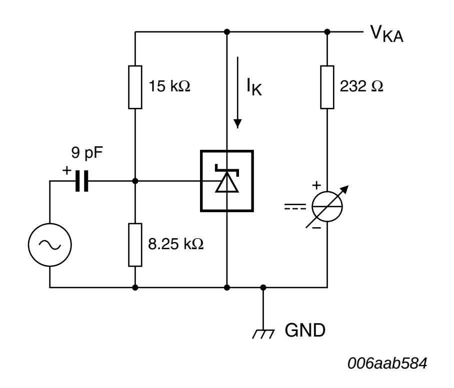
I_K = 10 mA; T_{amb} = 25 °C

Fig 14. All types except TL431XSDT: Voltage amplification as a function of frequency; typical values



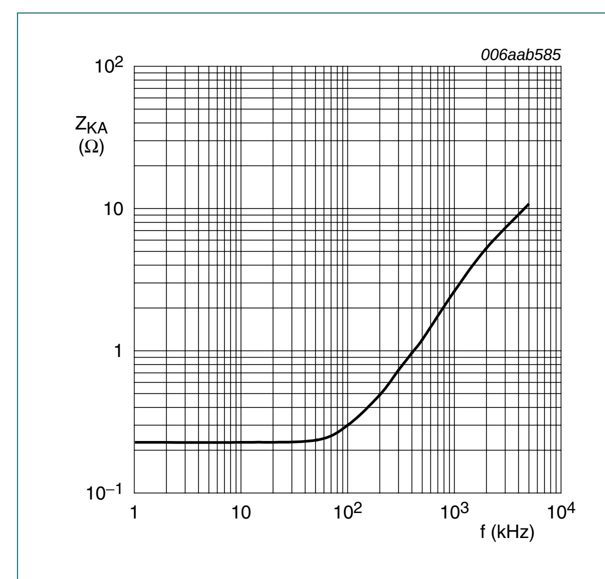
I_K = 10 mA; T_{amb} = 25 °C

Fig 15. TL431XSDT: Voltage amplification as a function of frequency; typical values



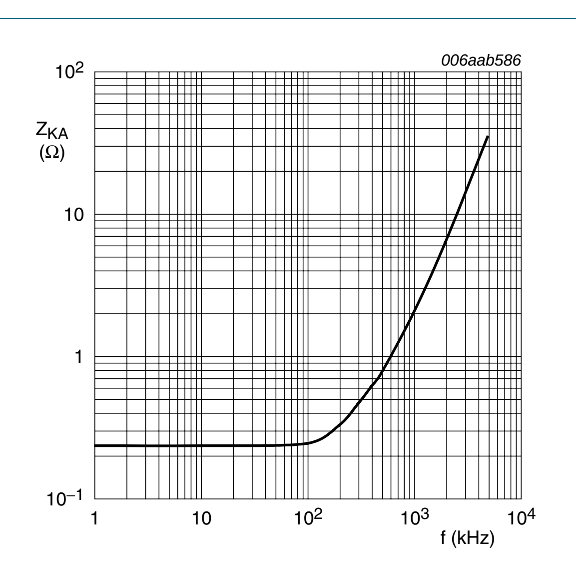
I_K = 10 mA; T_{amb} = 25 °C

Fig 16. Test circuit to Figure 14 and Figure 15



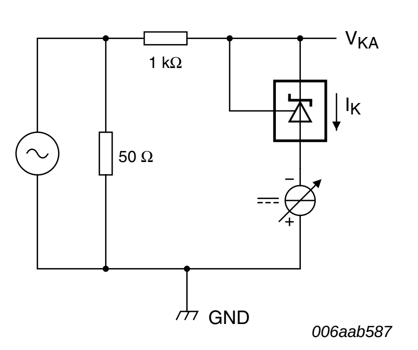
I_K = 10 mA; T_{amb} = 25 °C

Fig 17. All types except TL431XSDT: Dynamic cathode-anode impedance as a function of frequency; typical values



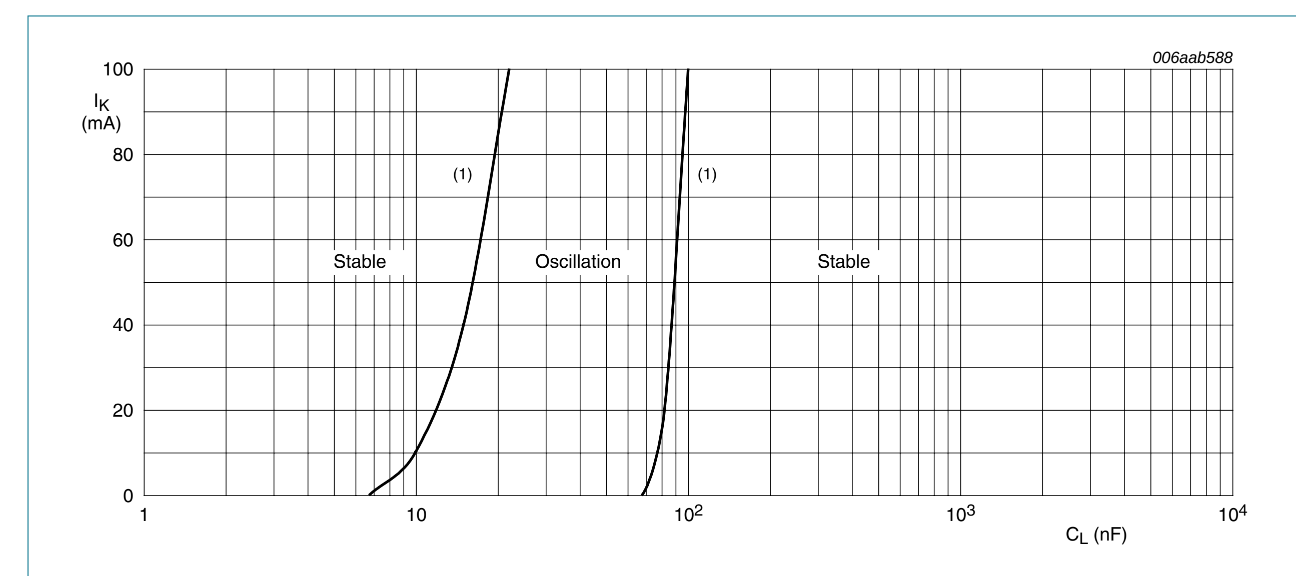
I_K = 10 mA; T_{amb} = 25 °C

Fig 18. TL431XSDT: Dynamic cathode-anode impedance as a function of frequency; typical values



I_K = 10 mA; T_{amb} = 25 °C

Fig 19. Test circuit to Figure 17 and Figure 18



T_{amb} = 25 °C

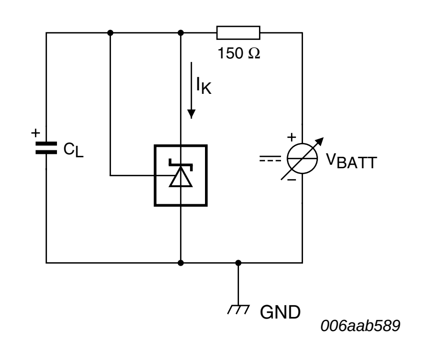
(1) $V_{KA} = V_{ref}$

V_{KA} = 5 V: no oscillation

V_{KA} = 10 V: no oscillation

V_{KA} = 15 V: no oscillation

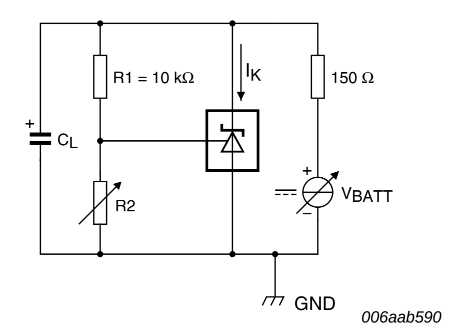
Fig 20. All types except TL431XSDT: Cathode current as a function of load capacitance; typical values



$V_{KA} = V_{ref}$

T_{amb} = 25 °C

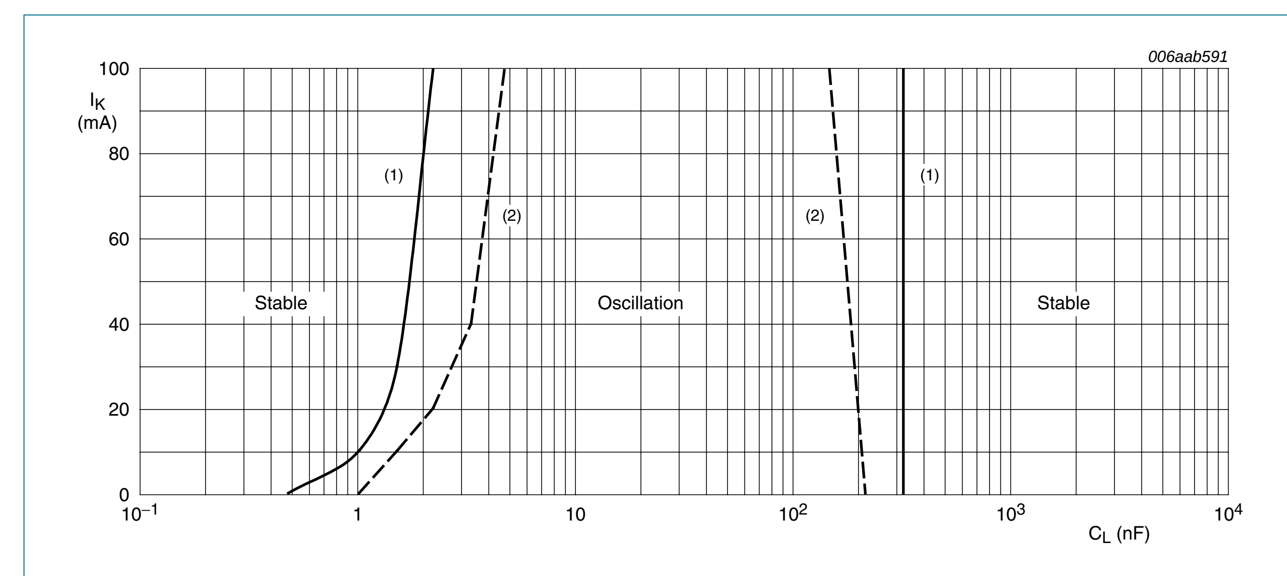
Fig 21. Test circuit (1) to Figure 20



V_{KA} > 5 V: stable operation

T_{amb} = 25 °C

Fig 22. Test circuit (2) to Figure 20



T_{amb} = 25 °C

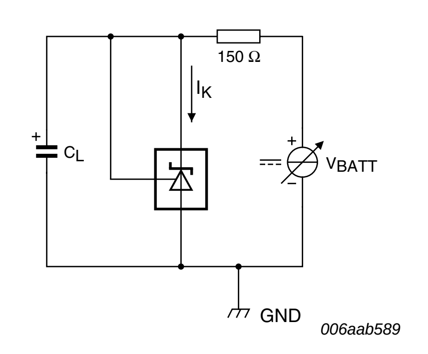
(1) $V_{KA} = V_{ref}$

(2) V_{KA} = 5 V

V_{KA} = 10 V: no oscillation

V_{KA} = 15 V: no oscillation

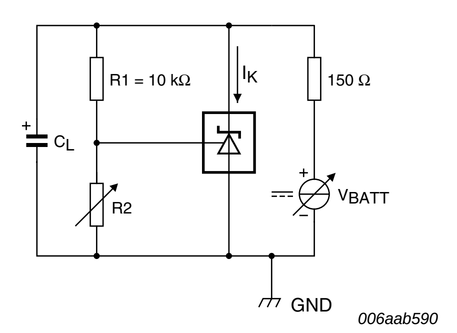
Fig 23. TL431XSDT: Cathode current as a function of load capacitance; typical values



$V_{KA} = V_{ref}$

T_{amb} = 25 °C

Fig 24. Test circuit (1) to Figure 23



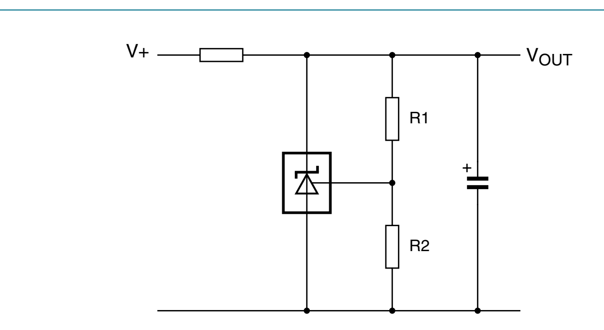
V_{KA} = 5 V

V_{KA} > 10 V: stable operation

T_{amb} = 25 °C

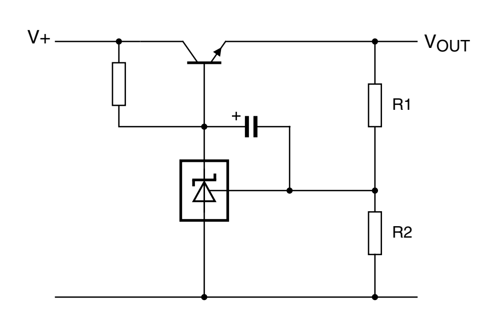
Fig 25. Test circuit (2) to Figure 23

13. Application information



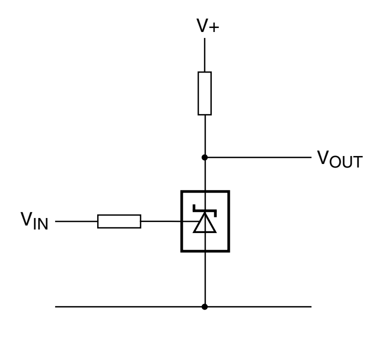
$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) \times V_{ref}$$

Fig 26. Shunt regulator



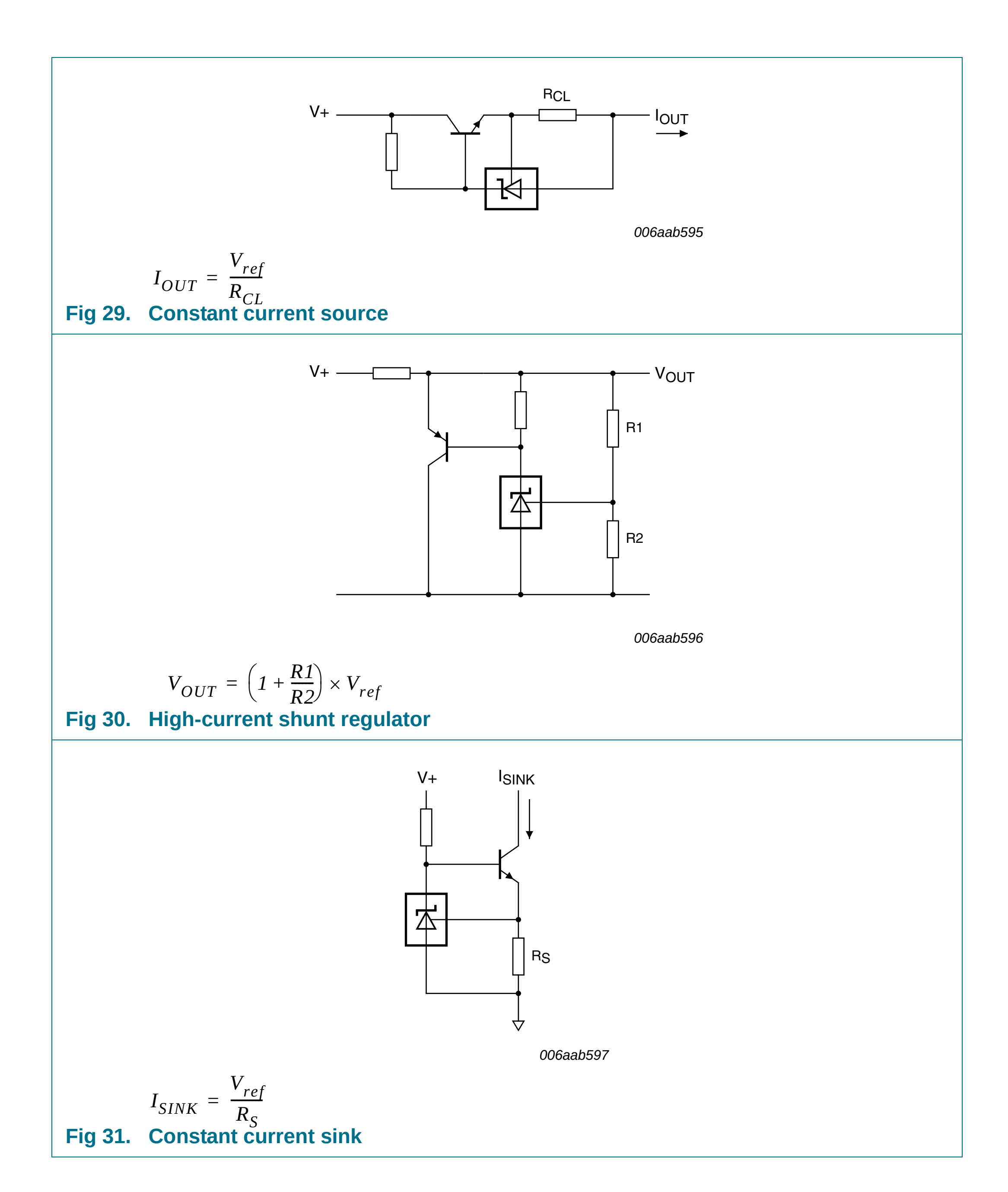
$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) \times V_{ref};\ V_{OUT(min)} = V_{ref} + V_{be}$$

Fig 27. Series pass regulator



$$V_{th} = V_{ref}$$
$$V_{IN} < V_{ref} \Rightarrow V_{OUT} > 0$$
$$V_{IN} > V_{ref} \Rightarrow V_{OUT} \cong 2V$$

Fig 28. Single-supply comparator with temperature-compensated threshold



$$I_{OUT} = \frac{V_{ref}}{R_{CL}}$$

Fig 29. Constant current source

$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) \times V_{ref}$$

Fig 30. High-current shunt regulator

$$I_{SINK} = \frac{V_{ref}}{R_S}$$

Fig 31. Constant current sink

14. Test information

14.1 Quality information

This product has been qualified in accordance with the Automotive Electronics Council (AEC) standard *Q100 - Failure mechanism based stress test qualification for integrated circuits*, and is suitable for use in automotive applications.

15. Package outline

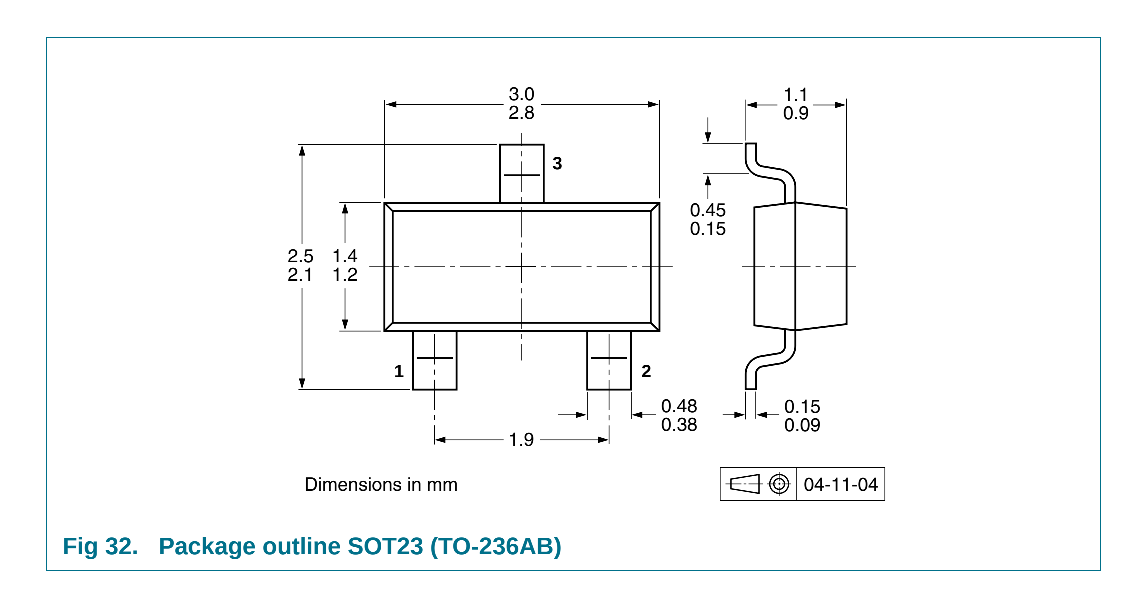


Fig 32. Package outline SOT23 (TO-236AB)

16. Packing information

Table 11. Packing methods

The indicated -xxx are the last three digits of the 12NC ordering code.[1]

Type number	Package	Description	Packing quantity	
			3000	10000
TL431CDBZR	SOT23	4 mm pitch, 8 mm tape and reel	-215	-235
TL431IDBZR				
TL431QDBZR				
TL431SDT				
TL431MSDT				
TL431ACDBZR				
TL431AIDBZR				
TL431AQDBZR				
TL431ASDT				
TL431AMSDT				
TL431BCDBZR				
TL431BIDBZR				
TL431BQDBZR				
TL431BSDT				
TL431BMSDT				

[1] For further information and the availability of packing methods, see Section 20.

17. Soldering

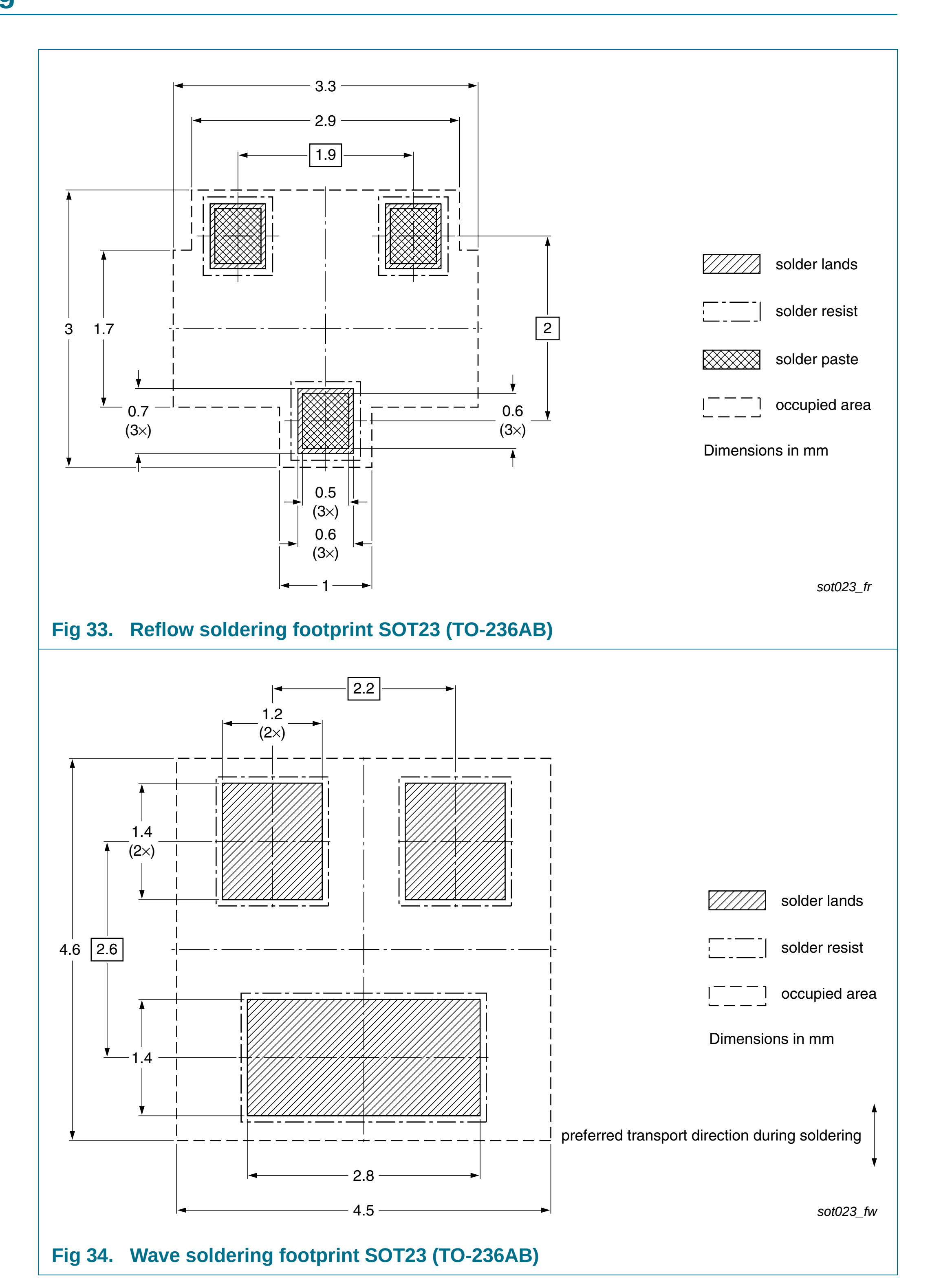


Fig 33. Reflow soldering footprint SOT23 (TO-236AB)

Fig 34. Wave soldering footprint SOT23 (TO-236AB)

18. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
TL431_FAM_2	20100120	Product data sheet	-	TL431_FAM_1
Modifications:	• Type numbers TL431BSDT and TL431BMSDT added • Section 7 “Functional diagram”: figure reference updated			
TL431_FAM_1	20090806	Product data sheet	-	-

19. Legal information

19.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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21. Contents



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